RESPONSES TO COMMENTS

In October 1999, NMFS released four DRAFT White Papers for regional review. For the White Paper entitled - "Salmonid travel time and survival related to flow management in the Columbia River Basin", review comments were received from the Idaho Water Users Association, Inc. (IWUA), IDACORP, Inc., Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, Columbia Basin Fish and Wildlife Authority, Washington Department of Fish and Wildlife, Columbia River Inter-Tribal Fish Commission, and Fish Passage Center. The comments fell into three general categories: 1) those that were minor text changes to clarify points; 2) those that provided suggestions on ways to improve the text to clarify analyses used or to conform with existing data; and 3) those that suggested that conclusions drawn were either not supported by the data or based on incorrect analyses. NMFS carefully considered the comments and modified the text where it deemed the comments appropriate. Where it appeared that the comments reflected a misunderstanding of what NMFS considered important points, a clarification to the text was made. Where NMFS did not agree with the comment, the text remained unchanged.

Many of the comments were repeated by more than one reviewer. We separated comments into categories identified above, and provide the following responses on how we addressed them.

I. Minor text corrections:

a. Table 1 should distinguish between Columbia and Snake

Concur. The new version does this.

b. Petrosky and Schaller 1998 should be changed to Marmorek et al. 1998, Appendix B. - Bouwes et al.

Changed.

c. "Snake River Hatchery Chinook SAR ... analysis is problematic and should be deleted..." **-** ODFW p.2

Concur. Deleted.

d. "The presentation of data in Figure 17 [estimates of survival through the hydrosystem across years] ... should be omitted." **-** ODFW p. 2

Concur. Omitted.

e. "... NMFS fails to mention ... that the Giorgi [1994] study ... found no significant flow/travel time relationship in the lower Columbia River." **-** IWUA p. 13

Mentioned in updated draft.
f. "Regardless of the improvements to in-river survival, the SAR's of in-river fish have averaged less than 0.5%..." Bouwes et al. p 15

We agree with this statement. No text change necessary.

g. "The thermal regime of fall chinook is also heavily influenced by the cooler temperatures of the Salmon River. Historically, the majority of fall chinook spawned above the confluence of the Salmon and Snake Rivers where water temperatures were warmer and emergence time was earlier. Studies by Idaho Power Company have shown that Brownlee Reservoir has limited temperature control capability." ODFW p. 2

We concur that Snake River fall chinook salmon are affected by the thermal regime. Idaho Power is currently studying the possibility of installing a selective withdrawal system at Brownlee Reservoir for thermal regulation.

h. "... photoperiod provides a better basis to predict travel time [of Snake River spring chinook salmon] than flow ..." IWUA p. 7

This conclusion is based on an *ad hoc* analysis (comparing mean R^2 values) that would not measure up to scientific scrutiny. We do acknowledge that smoltification level (for which photoperiod is likely a surrogate) is important in determining migration rate, and we elaborate on this point in the new version of the white paper. This does not diminish the fact no study has *failed* to find a travel time/flow relationship for Snake River spring chinook salmon.

II. Comments for improvements to text

a. "We are ultimately interested in total survival on a seasonal or annual basis, and across years ..." Bouwes et al. p. 15, USFWS p. 3 *"... flow-survival relationships using annual means are more meaningful ..."* ODFW p. 1

We agree that survival across years and to adults is the most important factor. It is not possible to disaggregate most data collected to date to determine if differences in return rates for groups of fish that migrated downstream vary under different flows. Thus, analyses have, by necessity relied on annual rates of return. But, with the advent of PIT tags, there is future potential to determine differences in return rates related to timing of migrations, flow, conditions in the estuary or ocean, etc. We believe these are important issues, so we can not agree that only annual measures of survival are meaningful.

b. "The paper needs to reconcile why a strong statistically significant flow-survival correlation based on reach PIT tag data exists for subyearling but not yearling migrants ..." ODFW p. 2

"The flow survival relationship for fall chinook contradicts NMFS conclusion that there is no flow survival relationship for spring chinook." FPC p. 5

The strong flow/survival relationship demonstrated for subyearlings was based on fish released as pre-smolts in rearing areas. These fish undergo extensive rearing before they are detected at Lower Granite Dam. Spring migrants observed from Lower Granite to McNary Dam are active migrants that undergo little rearing during this period. There is no reason to expect similar results for different sub-species observed at different stages of their life-histories.

c. "... it is not surprising that no relationship emerged between median travel time and environmental variables for releases above LGR. The confounding effect of rearing may mask these relationships and should be discussed here." Bouwes et al. p. 18

We concur and have described the complexity of the behavior in the revised paper.

d. ".. per-project survival rates are a coarse measure of effects of flow on in-river survival. ... much poorer turbine and bypass survival [existed] before 1980..." Bouwes et al. p. 18

We concur. However, the studies in the 1970s did not take into account differences in passage survival related to changes in turbine operations or debris. We include the earlier data for illustrative purposes only. We base our conclusions on the existence of flow/survival relationships on data collected under current conditions.

e. "We have always placed higher value on findings based on smolt-to-adult returns than juvenile survival data. ... Flow-survival analyses based on juvenile survival data should be presented as corroborating evidence supporting flow-SAR findings" ODFW

We concur that the ultimate measure of stock performance should be something that covers as much as the life-history as possible – e.g., SARs or recruits-per-spawner. However, it is difficult to attribute variability of these measures to factors that occur during one stage of the life-history. In addition, factors such as seasonal flows are correlated with other influential factors such as overwintering conditions in tributaries and ocean conditions. Therefore, if a direct effect of flow on survival can be measured, we feel this is an extremely important piece of information.

f. "It would take many, many years of data to tease out the most important physical variables [related to survival of Snake River fall chinook salmon]" Bouwes et al. p 21

We agree that fully understanding the mechanisms behind the relationships between survival and environmental factors will be difficult for Snake River fall chinook salmon. Particularly difficult will be separating the effects of flow and temperature. If the region wants to make a serious commitment to manipulating the system in an effort to get a better understanding of how Snake River fall chinook salmon respond to variable river conditions, it is likely feasible to conduct such an experiment above Lower Granite Dam because of the different sources of water (Dworshak and Brownlee) available for augmentation.

g. "Factors such as higher spill levels increase survival [and thus confound efforts to establish flow-survival relationships] ... Therefore, we would expect a higher survival in 1995 and 1996 compared to 1994 ..." FPC

Concur. Survival estimates were higher in 1995 and 1996 than in 1994 and 1993, possibly due to the implementation of the spill program after the 1995 BiOp. Note that the per-project survival estimates for 1993 and 1994 fall below the trend line in Figure 10 (in the old version of the white paper). However, 1994 was never included in the detailed PIT tag analysis in the white paper, so this fact has no bearing on the results presented there.

h. "The scientific data support the conclusion that the potential for altering thermal dynamics of the Clearwater system to more closely mimic the Snake River has more potential for helping fall chinook than altering the Snake River." Idaho Power p. 2

We concur that fall chinook salmon emanating from the Clearwater River are subjected to cooler water temperatures during their rearing period, which may lead to a later outmigration, and that temperature regulation could help these fish. The paper discusses the potential effects of temperature on all sub-populations of fall chinook salmon in the ESU.

i. "... the paper states: 'However, direct juvenile salmon mortality had increased sufficiently to decrease adult returns (p. 1)'. This statement implies that decline of salmon is primarily attributable to changes in flow due to dam development." IWUA p. 2

Nowhere is it implied that decline in adult returns is primarily attributable to changes in flow. But as it is difficult to attribute declines in salmon abundance to any one factor, this statement was deleted.

j. *"... the 25th and 75th percentiles of cumulative passage ... encompasses the middle 50 percent of the run [of Snake River fall chinook salmon from point of release to detection at Lower Granite Dam]." "Use of only the fifth percentile cumulative passage ... leaves unanswered the association between environmental variables and the 10th, 25th, 50th, 75th, etc. percentiles. In particular, use of the fifth percentile leaves unanswered questions about the remaining 95 percent of total migrants upstream from Lower Granite Dam."* IWUA p. 9

We concur that no exposure index is perfect, and the choice of index can potentially affect results. However, in the case of Snake River fall chinook salmon from point of release to detection at Lower Granite Dam, exposure indices based on release date to 5th, 10th, 20th, 25th, and 50th cumulative passage percentiles are very highly correlated for flow, temperature and turbidity. Also, as residence time for these fish is protracted, exposure indices based on the 25th to 50th percentiles ignore the majority of time that fish are in the river. The paper was modified to make these points more clearly.

k. "... important research is omitted altogether. For example, Skalski (1998) found survival of yearling chinook between Lower Granite and Little Goose to be 'Remarkably stable over the course of the season.'" IWUA p. 14

To imply that NMFS is trying to skew "the weight of evidence" by not including this report is absurd. Skalski (1998) comes to the same conclusion for one year of data as NMFS does over the 4-year analysis reported in the white paper. However, we do cite the Skalski (1998) paper in the new version of the white paper.

l. "Particularly troubling is the suggestion that temperature control be used to more closely approximate historical conditions. Most scientists caution against taking actions based simply on how closely they approximate pre-dam environment... In the pre-dam system, the vast majority of the fall chinook in the upper Snake River spawned above Brownlee Dam ..." IWUA p. 15 *"Another issue is that the existing outlet works from the dams in Hells Canyon are mid-elevation facilities. Although an extremely expensive retrofit of multi-level outlet works might be technically possible, it is not clear that the pool behind Brownlee Dam has significant temperature stratifications year-round."* IWUA p. 15

We concur; simply trying to mimic historical conditions is naive. The goal is to restore threatened and endangered salmonid populations. As noted elsewhere, hydroelectric development in the upper Snake River has severely affected populations of fall chinook salmon to the point that their major freshwater habitat has changed. Returning to historical conditions is not relevant for these fish. However, previous research has shown that changes in water temperatures have changed the timing of fall chinook salmon spawning in the Snake River. Subsequent emergence of fry and growth is also delayed, in turn delaying the start of downstream migration. The later the fish migrate, the worse the passage conditions. Changes in temperature regimes from present conditions might lead toward more favorable conditions and higher survival of fall chinook salmon.

Ebel and Koski (1968) showed that Brownlee Reservoir is highly temperature-stratified beginning in May.

III. Comments that disagreed with text

a. "... observed intra-annual variability in flow conditions cannot be considered an experimental treatment, with high power to detect an effect of flow on survival of tagged groups released a week or so apart, perhaps overlapping temporally lower in the hydrosystem." Bouwes et al. p. 14 *"The problems presented by variability in environmental conditions smolts are exposed to and biological differences between study groups confounds survival estimates resulting in poor* *correlations. NMFS's study protocol was not designed to detect within-year flow-survival relationships primarily due to within-year variability in project operations (i.e., spill) which affects detection probabilities and survival estimates."* ODFW p. 1 *"The juvenile survival estimation methodology can not define a flow/survival relationship from the data record available. It can develop useful annual indices of survival over long river reaches."* FPC p. 6 *"During the course of a given year a series of about 10 releases...may be spread out [over the primary passage period]...These releases do not provide 10 independent estimates of survival versus flow, however."* FPC p. 6

NMFS's study protocol was not designed to detect within-year flow-travel time relationships, yet found them for spring migrants. NMFS's study protocol was not designed to detect within-year exposure-survival relationships for fall chinook salmon, yet found them. This suggests that if the protocol and analysis methods mask a flow-survival signal for spring migrants, then it's a weak signal.

NMFS is currently in the midst of a large-scale Monte Carlo study investigating flow-survival relationships and the analyses we have used to try to detect them. Given the complexity of the processes that give rise to the data, each simulated scenario takes considerable computing time to complete. A study that includes the total number of scenarios we wish to explore will take several months. However, we are encouraged by early results: relatively weak flow-survival signals have been detected using the regression methodology. Statistical power is not always great, but to date we have found no scenarios that include a biologically meaningful flow-survival signal, yet result in regression analyses with results comparable to those in the analyses of observed data reported in the white paper.

We recognize concerns regarding independence of release groups, and overlapping of passage distributions leading to decreased variability in flow indices. Expression of these concerns in various forums is used to suggest that the entire analysis should be ignored. Consequently, it was more than a little surprising to see the analysis of spill levels (FPC p. 9) based on ANOVA and t-tests of survival estimates from releases on 5 or 6 consecutive days. If the independence requirements for these tests are met, then surely those for linear regression are as well.

b. "There are a series of factors that potentially interact to determine the effect of flow on survival ..." Bouwes et al. p. 14 *"... survival estimates were [not] used as a dependent variable in multiple regression; i.e., the combined or interacting effects of flow, spill, turbidity, and temperature were not examined as predictors of survival rate."* Bouwes et al. p. 19 *"... environmental variables act in concert and affect survival rates in biologically meaningful ways."* USFWS p.3

We concur that there is potential for environmental factors to interact in their effects on survival. Multiple regression, particularly with interaction among independent variables, might improve model fits. However, in cases where univariate regressions over a number of years yield no significant relationships (e.g. regressions with Snake River spring migrants comparing survival estimates to flow exposure), we consider it doubtful that a multiple regression approach would uncover any new information. In the case of Snake River fall chinook salmon, with regressions of survival from release to Lower Granite on flow, temperature and turbidity exposure indices, the environmental variables are so highly correlated that a multiple regression analysis is highly unlikely to determine which factors are most important in determining survival. Nonetheless, we intend to explore multiple regression approaches in future analyses of these data.

The only way to demonstrate some of these effects with a high degree of confidence is to conduct controlled experiments. Unfortunately, it is extremely difficult to define control and treatment groups that only differ in a treatment (such as flow augmentation). Within-season treatments would be difficult to conduct because of the protracted migrations of release groups. Year-to-year treatments would require many replications due to confounding effects.

With these limitations in mind, we are required to use the best available information, which, at this point in time, is the results of survival studies. In the future, it may be possible to manipulate the system to limit the confounding effects of correlated variables.

c. "... there are cumulative and delayed effects of hydrosystem stress on mortality..." Bouwes et al. p. 14 *"... these cumulative and delayed effects or complex interactions are not likely to be revealed based on in-season relationships with flow indices..."* Bouwes et al. p. 15

We consider delayed mortality due to passage through the hydropower system a plausible but untested hypothesis. Its existence cannot be stated as fact. On a related note, flow augmentation may affect survival outside of the hydropower system. This was stated in the first draft (September 1999) and expanded upon in the second draft (April 2000).

d. "... the flow exposure index used in these relationships is a median value of a range of flows that are measured at only one point in a long and variable hydrosystem..." Bouwes et al. pp. 14-15. *"The definition of the environmental variable by averaging and the inter-dependence of environmental variable suppresses the identification of a flow/survival relationship."* FPC p. 5 *"Measures of average flow...would tend to reduce differences in flow [index] among the release groups. With BiOp flow targets being applied, there would be even less differences in flow [index] among release groups.* FPC p. 6 *"NMFS collected all their flow/survival data under conditions that were guided by the biological opinion flow recommendations."* FPC p. 7

The flow exposure index is not a median value. It's the mean of daily values measured at Lower Monumental Dam during a defined time period. The analyses for spring migrants are based on fish leaving Lower Granite Dam between 1 April and 31 May. Between Lower Granite Dam and the mouth of the Snake River during this time of year, flow conditions vary minimally between dams and between days. The conditions a group encounters as it passes Lower Monumental Dam are very much like the conditions it encounters throughout its entire migration through the Lower Snake River.

Averaging and interdependence also suppress identification of a flow/travel time relationship, yet one was found. Biological opinion flow recommendations were in effect, yet flow exposure indices have had wide ranges: 62-141 kcfs in 1995, 86-193 kcfs in 1996, 100-231 kcfs in 1997, 65-207 kcfs in 1998. (It is true that the lowest flow levels observed in 1973 and 1977 were not observed during the course of this study).

All questions regarding independence, averaging of flow measures, and overlapping passage distributions aside, a couple of indisputable facts are deducible from the observed data: (1) intra-annual variability in survival was small; (2) flow exposure for groups leaving Lower Granite Dam varied throughout the season. Whether the particular index of flow exposure we have developed is the appropriate way to characterize that exposure, it is undeniable that within a single season there were groups that, as a group, experienced vastly different flow levels as they migrated through the Lower Snake River. Regardless of how the observations are analyzed, it is difficult to reconcile the observed data with belief in a strong and direct effect of flow level on direct survival of smolts migrating through the Lower Snake River in April and May.

e. "Deriso et al. (1996) estimated the differential instantaneous mortality ("mu") between Snake River and lower Columbia stream-type chinook, ... and plotted mu vs. water travel time..."

This analysis is based on the assumption that downstream stocks are suitable controls for upstream stocks. We believe this methodology is flawed. See Zabel and Williams (*in press*).
Recently published draft (preliminary) results from the comparative survival study also suggest that this is not the case.

f. "Analyses conducted by ODFW do show flow-survival relationships for spring chinook juveniles (Attachment 2)"

These analyses are based primarily on outdated information (Sims and Ossiander data). Because of large amount of uncertainty over the level of dam mortality during these years, they are not reliable for illustrating flow/survival relationships under current conditions.

g. "We have not had conditions that duplicated the 1973, 1977 conditions of the earlier data set. If we did have these conditions we would expect to have a significant decrease in survival." FPC p. 8

We agree survival would likely decrease, but there is no evidence to suggest that it would decrease significantly. In addition to low flows that existed in 1973 and 1977, the heavy debris accumulation in the forebay of dams and dam operations had a profound effect on juvenile survival (Williams and Mathews 1995). In submission 9 to the Weight of Evidence Report for PATH, NMFS previously provided modeling evidence that under lower flows similar to 1973, the survival of migrants through the Snake River in 1992 was apparently considerably higher than that which occurred in 1973.

h. "The white paper appears to be proposing to manage the system [Hell's Canyon complex] so that winter temperatures are higher while summer temperatures are lower. That appears counter to a natural river thermal regime..." Idaho Power Company p. 2 "The speculation that warming the Snake River during winter and spring months may enhance recovery of fall chinook lacks scientific merit..." Idaho Power p. 2

Ebel and Koski (1968) showed that in the spring, the temperature of the water leaving Oxbow Dam is cooler than the water entering Brownlee reservoir. In the fall, water leaving Oxbow Dam is warmer than the water entering Brownlee reservoir, which appears to have created conditions detrimental to adult survival and spawning (Ebel and Koski 1968). In the latest version of the white paper, we have included a plot of median passage date at Lower Granite Dam for wild Snake River fall chinook salmon versus mean temperature of Snake River water measure over the first six months of the year. This plot demonstrates the potential to shift migrational timing by altering the temperature regime.

i. "... benefits of flow are justified with phrases like "data indicate," "would likely" and "may provide." Clearly these qualitative and subjective phrases are used because a relationship between flow and survival has not been quantified, nor is it likely to be quantified." (Idaho Water Users Association (IWUA) p. 2

In ecological studies, it is rare that one can be certain beyond a doubt about any conclusion. Scientific judgment involves accumulating information through time and determining which conclusions are supported by the preponderance of evidence. It would be unfair to characterize something as certain when it is not. At the same time, lack of 100% certainty does not indicate that relationships do not exist. It is clear that salmon migrating downstream through the hydropower system do so under flow conditions that are different than those under which they evolved. This is particularly true once the fish get below Bonneville Dam. Suggesting more natural flows are better for fish is not inconsistent. It is not the role of science to make the management decision of when the costs of flows are too high to outweigh presumed benefits for the fish.

j. "Flows from the upper Snake Basin are virtually the same as they were 85 years ago." IWUA p. 3 *"... the flow quantity [from] the Snake River has not changed significantly over the past 85 years. Thus any changes [to] the estuary or ... plume are not the result of upstream development on the Snake River. Further, the [Snake River] flows required to make significant changes in the estuary ... are large ..."* IWUA p. 4 *"The White Paper should be substantially revised to incorporate a comprehensive review and discussion of the hydrology of the Snake and Columbia Rivers. Particular emphasis should be placed on the Snake River system where populations of the listed species of most concern are located."* IWUA p. 4

We concur that a better understanding of hydrology would be helpful. We did expand Table 1 to indicate how flows have changed over time in the Snake and upper Columbia Rivers. However, hydrology is not the focus of this paper. The focus is on studies that measure the reaction of salmonid populations to variable environmental conditions. We also need to dispel the notion that the Snake River stocks are of most concern. Eight other salmonid ESUs are listed as endangered or threatened in the Columbia River Basin. Upper Columbia stocks are worse off than Snake stocks (excluding Snake River sockeye salmon) according to the latest CRI extinction analyses. Further, flow from the Snake River itself, though, is not the only important factor for salmon survival; water velocity and temperature are also important. These factors have changed drastically as a result of development of the hydropower system, including on the Snake River above the confluence with the Clearwater (Ebel and Koski 1968). Although flows in the Snake River have not changed, travel time of migrants has increased significantly due to the development and operation of the hydropower system.

k. "... flow augmentation is futile to mitigate the velocity reduction due to dams on the lower Snake River ... More than 160 MAF would be required to restore pre-dam velocities." IWUA p. 4

Nowhere in the white paper is the unrealistic goal of affecting pre-dam water velocities through reservoirs considered. Also, flow augmentation can be used for purposes other than increasing water velocity, such as temperature regulation, decreased delay at dams, and increased spill. Additionally, each incremental improvement in flow helps to return the river to a more normative condition. The incremental effects of water withdrawal throughout the system have also changed the hydrology of the river from conditions under which the fish evolved.

l. "... there does not appear to be a relationship between travel time and survival [for Snake River fall chinook salmon]. This strongly indicates that other river conditions ... may be more important to survival than simply the quantity of flow." IWUA p. 9 *"there is credible and important scientific evidence that temperature is the operative variable affecting survival, not flow."* IWUA p. 10

The highly speculative nature of these comments is ironic given your criticism to NMFS for speculative conclusions. Alternative explanations should be held to the high standards you demand of NMFS. We discuss the effect of temperature and flow and provide text on potential effects of both on survival in the final White Paper.

m. "Although flow and survival exhibit a positive and linear relationship at low flows ..., the relationship is flat above 120 kcfs. ... This is a strong indication that whether the relationship is correlative or causative, it breaks down." IWUA p. 10

Our analyses contained in the white paper conclude that above 120 kcfs, the relationship between survival and flow flattens out. Nonlinear relationships and threshold phenomena in biology are very common. To say that the relationship “breaks down” because it is not strictly linear through its entire range is speculative. Further, most flow augmentation will occur at background flows below 120 kcfs. We also provide text discussing how high flows (in 1997) were probably detrimental to survival by flushing rearing parr out of the system before they were ready and increasing the debris load at the dams.

n. “In recent years, the Raymond and Sims and Ossiander research has been discounted ... However, the studies criticizing the dated research are not even discussed or cited in the White Paper.” IWUA p. 12

We don’t use data from any of these studies to support our conclusions, therefore we do not make any effort to criticize these data.

o. “... older research that does not consider changes in the hydrosystem over time ... is still relied upon.” IWUA p. 12

Wherever possible, we updated past analyses of SAR or recruit-per-spawner data. Furthermore, the white paper relies mostly on the recent PIT tag data, collected under current conditions.

p. “... the White paper reports an investigator’s [Connor et al. 1998] conclusions without noting fundamental problems with the research.” IWUA p. 13

We reported results from a peer-review journal article and attributed the conclusions about the potential of flow augmentation to improve survival to the authors. Disagreements with scientific articles are properly addressed by writing a rebuttal article, submitting it to the journal for peer review, and having it published.